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CHALLENGE TO AVIATION - HATCHING A LEANER PTEROSAUER

by Senator Frank E. Moss

Presented at NASA Lewis Research Center, Cleveland, Ohio, May 13, 1975

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Senator Frank E. Moss
Chairman, Committee on Aeronautical and Space Sciences

Senator Frank E. Moss (D-Utah), in addition to being Chairman of the Aeronautical and Space Sciences Committee, has strong legislative interests in energy, where he has authored a number of bills. He has initiated and chaired numerous hearings on energy problems as a member of the Subcommittee on Minerals, Materials, and Fuels. Senator Moss is also widely known for his interests in the conservation of natural resources and particularly for his work in the field of water resources. He is a member of the Budget, Commerce, and Post Office and Civil Service Committees as well as the Special Committee on Aging. Senator Moss is Secretary of the Democratic Conference, the number three party position in the Senate, and serves on the Democratic Policy and Steering Committee. He was first elected to the Senate in 1958 where he has established himself as a leading advocate of consumer interests.

A native of Salt Lake City, Senator Moss received a B.A. degree, magna cum laude, from the University of Utah and a Juris Doctor, cum laude, from George Washington University Law School. He obtained considerable legal experience both in private practice and as a judge, and he served for four years in the European Theater with the U.S. Army Air Force. He has served as an officer of numerous legal associations, and his participation in a variety of fraternal and civic activities includes membership on the Board of Regents of the Smithsonian Institution. He has received a variety of awards including the Distinguished Alumni Award from George Washington University in 1963 and an Honorary Doctor of Law from the University of Utah in 1973.

CHALLENGE TO AVIATION - HATCHING A LEANER PTEROSAUR*

Senator Frank E. Moss **

Scientists recently discovered, in Texas naturally, the fossilized remains of the world's largest flying creature - a reptile called the pterosaur. Its wingspan was over 50 feet, greater than most fighter airplanes. The problem was that this jumbo buzzard dined on dead dinosaurs, which gradually became a rather scarce aviation fuel, even in prehistoric Texas. Soon thereafter, the pterosaur declined.

Ladies and gentlemen, I'm concerned that history may repeat itself. Texas and the world around fear that the day is coming when oil may go the way of the dinosaur - an ironic historical twist. How can we continue feeding our twentieth century pterosaurs? Perhaps the answer is to hatch a new generation of them, a leaner, more fuel efficient version.

Four months ago I wrote Dr. Fletcher, the Administrator of NASA, asking him if NASA could establish, in collaboration with industry, a technology demonstration goal to make possible a much more fuel efficient generation of commercial aircraft. NASA's response has been most encouraging. In recent testimony before the Senate Committee on Aeronautical and Space Sciences, NASA officials expressed their preliminary assessment: If a fuel efficiency program is pursued successfully, commercial aircraft produced in the late 1980's could be designed to use 50 percent less fuel than the present fleet.

Some observers have said that the most dramatic reductions in aviation fuel consumption are achievable without modifying the basic aircraft design at all. They point to our very inefficient use of commercial aircraft.

It is true that if passenger load factors were to reach only 70 percent, fuel savings would be 25 percent better than in pre-oil-crisis days. And the installation of high density seating in our transports could further boost the overall efficiency.

Current CAB regulation prohibits air fare competition among the airlines, but competition still exists in the form of route scheduling wars and accommodations contests - wider seats, newer movies, shorter skirts.

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*After dinner address to the Aeronautical Propulsion Conference, NASA-Lewis Research Center, Cleveland, Ohio, May 13, 1975.

**Utah. Chairman, Senate Committee on Aeronautical and Space Sciences.

Under this regulation we get quick reliable service from the airlines but we pay for it through lower load factors and higher fares. Recent events in Washington, such as National Airlines' proposal for a variety of fares for a given trip, suggest that load factors may rise dramatically in the next decade because of regulatory changes.

However, two considerations undercut, I think, the value of this approach: (1) The prospect of regulatory change is uncertain and speculative; and, mainly, (2) it does not lead to better aircraft.

If we put our effort into developing more fuel efficient aircraft, we accomplish several goals: (1) We save fuel; (2) we cut the operations costs of the airlines; (3) we create jobs and stimulate the aerospace industry; and (4) we get a more attractive product for export and domestic use. And, by the way, export of aircraft is the backbone of our hope for a favorable balance of payments (fig. 1).

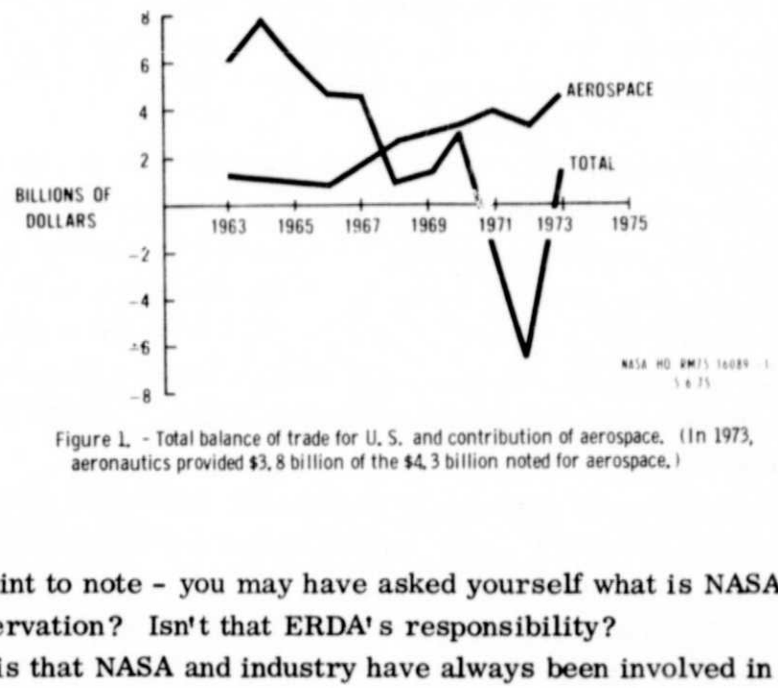

Figure 1. - Total balance of trade for U. S. and contribution of aerospace. (In 1973, aeronautics provided $3.8 billion of the $4.3 billion noted for aerospace.)

One other point to note - you may have asked yourself what is NASA doing getting into energy conservation? Isn't that ERDA's responsibility?

The answer is that NASA and industry have always been involved in the search for fuel efficiency. Every decrease in aircraft weight, decrease in drag, or improvement in engine efficiency is a step in the right direction. The airplane is such an interdependent system that no agency <u>but</u> NASA is equipped to tinker with it.

So what kind of improvements does NASA foresee in setting this remarkable goal of a 50 percent improvement? (See fig. 2.)

First, NASA engineers tell me that the use of the supercritical wing alone will result in a 10 to 15 percent overall economy improvement. The interesting thing about the supercritical wing is that the rising cost of fuel has changed its attraction

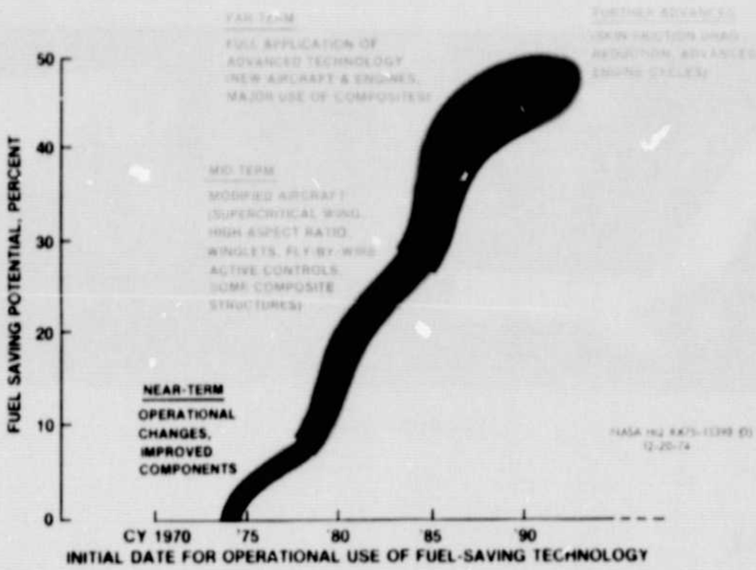

Figure 2. - Potential for aeronautical fuel conservation.

altogether. Originally, it was seen as a means of achieving supercritical cruise speeds, that is, cruise speeds closer to the sound barrier. But now rising fuel costs make higher speeds less appealing. Yet, an ancillary benefit of the supercritical wing is that the wing is fatter than conventional ones by about 50 percent. Because it is <u>fatter</u>, it can be made <u>lighter</u>. (Unfortunately, this same concept does not apply to people.) But being lighter the wing can be lengthened to increase the wingspan. And, as every aeronautical engineer knows, for reasons not altogether clear to most Senators, a bigger wingspan improves the aircraft efficiency and fuel economy.

To me the supercritical wing is a perfect example of the productivity of research. Research showed us how to change the wing shape into a simpler, lighter, and cheaper configuration that yields 10 to 15 percent more fuel economy. It is the closest thing I know to getting something for nothing but some R&D dollars.

The second innovation that NASA will apply to the fuel stretching generation of aircraft is the winglet (fig. 3). I'm told that this is just a small vertical plate added to the wing tip. Apparently, engineers have sought the right shape and size of the winglet for many years, believing that drag could be reduced. None ever worked. But at last, researchers have discovered just the right combination. Tests of current versions show a 5 percent increase in aircraft fuel economy for very little additional weight to the aircraft, and we think the winglet can be retrofitted to current aircraft. So they too will save money. It makes you wonder if aeronautics isn't more magic than science. After all, the alchemist of the Middle Ages and the aeronautical engineer seek the same end - to convert commonplace metal into gold. In the case of the winglet, we'll use aluminum

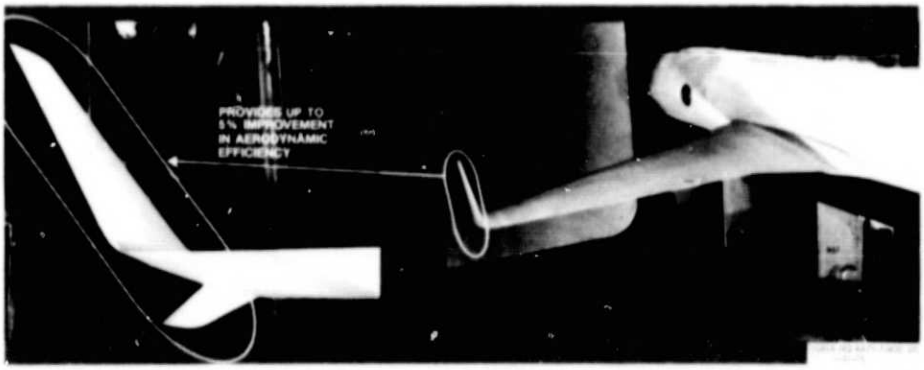

Figure 3. - "Winglet."

to make black gold.

The third candidate for the next generation of aircraft is advanced composite materials, which are twice as strong yet lighter than conventional materials. As you know, these composites consist of fibers of graphite, boron, or nylon embedded in plasticlike material. This technological breakthrough gives a double-barreled energy benefit. First, the weight savings will lead to an estimated 10 to 15 percent overall fuel savings. Second, manufacturing a pound of composite material requires only 15 percent of the energy required to manufacture a pound of aluminum and less than $2\frac{1}{2}$ percent of the energy needed to produce a pound of titanium. Thus with composite materials we save energy as we make them and as we use them.

NASA says that the obstacle to composites right now is the lack of flight experience with this material and its cost. But the cost is dropping fast as more composites are produced. To gain flight experience with composites, many transports in service today are fitted with selected parts made of composites in order to evaluate them (fig. 4). From what I have seen, the move from metal to composites in aircraft will be as significant as was the jump from fabric to metal.

Another advance will come in the propulsion systems of the next generation of aircraft. I would have expected that we have already pushed jet engines to their limits, considering that today's transports get three times the fuel economy of the 1958 jets. (After all, current automobiles get worse mileage than those of 1958.) Yet, another 5 to 10 percent improvement is expected to come from reduced clearances, better seals, and other black magic. And NASA claims that we have on the horizon more advanced engines with the preheated combustor inlet air concept, which may lower fuel consumption by another 10 to 20 percent over current turbofans.

One last innovation that may find its way into our next fuel-sipping generation of aircraft is what NASA calls active controls or fly-by-wire systems. I must confess that fly by wire left me cold for a while. Even if it is quadruply redundant, I would

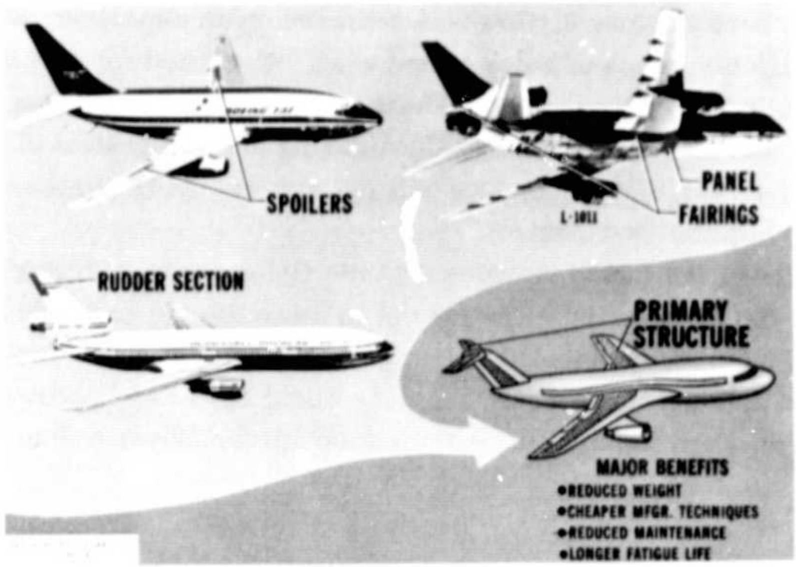

Figure 4. - Secondary structural components made of composite materials in operational use today on aircraft. (Later, composites will comprise primary structures yielding even greater benefits.)

feel a lot safer with good old-fashioned link rods and hinges between the pilot's hands and the rudder and elevator. However, an engineer pointed out to me that the control surfaces on the 747, which I think is a pretty safe airplane, are moved hydraulically because a man does not have the strength to move them with muscle. I have decided that perhaps "fly by wire" is no worse than "fly by hose." One thing for sure, fly by wire is here to stay.

An Air Force General recently told me that the F-16, and probably every Air Force fighter from now on, will be fly by wire. But, he said, the biggest payoffs from this system are in store for transports, not fighters. Fly by wire lets you build smaller and lighter airplane tails and even relax the requirements on where the center of gravity is, so more cargo can be carried. The plane flies more smoothly, too. So there is less weight, less drag, and more payload. NASA claims that the direct benefits alone of fly by wire and active control systems will give 5 percent better fuel economy.

Now, if we rub our NASA crystal ball a little harder, we can see even farther into the future of aviation - beyond the 1980's. Sometime ahead engineers may discover a long-sought cure for the aeronautical equivalent of the common cold, that is, turbulent airflow, which saps the fuel efficiency of aircraft. If the airflow over the wings, fuselage, and tail can be kept smooth (the engineers call it laminar), fuel economy will jump by 20 to 40 percent. That is a bigger gain than that promised by any other single innovation.

In the 1960's such laminar airflow was achieved on an experimental aircraft by sucking air through thousands of holes on the wing. It worked for a while, but I am told the holes eventually clogged with dust. There are many other schemes to achieve this laminar airflow, but so far none work. Considering the imagination of these NASA engineers, I fully expect that one day we will get this whopping improvement in fuel economy through laminar flow control.

Another vision of the future includes gigantic flying wings carrying payloads up to six times that of the 747 (fig. 5). The idea is to store the cargo inside the wing so that the load is distributed evenly instead of being concentrated in a fuselage. This way the wing can be made lighter. Of course, the wing would have to be about 10 feet thick, but that's not so tough; even Howard Hughes' plywood Spruce Goose had an 11-foot thick wing.

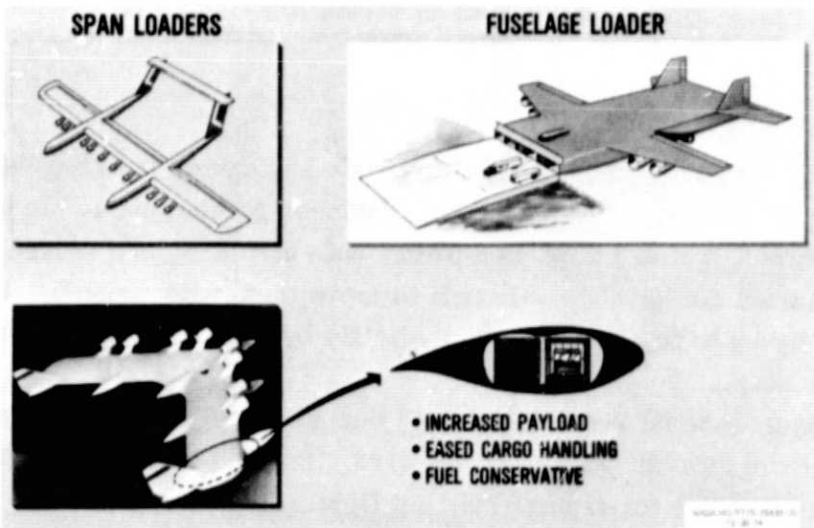

Figure 5. - Dedicated cargo aircraft concepts.

Finally, decades from now we probably will have other fuels for aircraft besides petroleum. Of particular interest is hydrogen, because, pound for pound, it has three times the energy of petroleum. Assuming storage problems can be worked out, hydrogen looks like an excellent aviation fuel. (See fig. 6.)

Getting that much hydrogen may look difficult now but, who knows, by then we may have a total hydrogen economy. I do believe that hydrogen will play an increasingly important role in our economy. First, to power the space shuttle, and later, as an energy storage medium that powers fuel cells as energy is required. Eventually, deuterium, a form of hydrogen, will be the fuel for fusion plants. Hydrogen itself might be

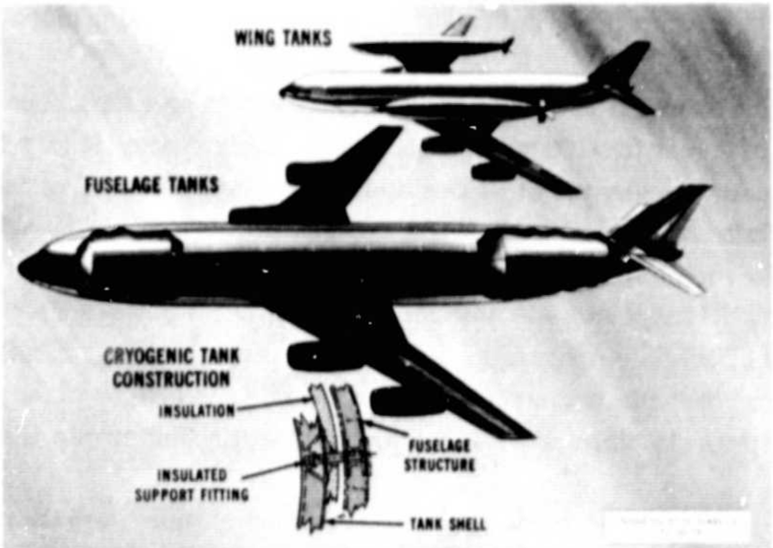

Figure 6. - Hydrogen-fueled transport aircraft concepts.

transported as natural gas is today and used as a substitute for petroleum in airplanes and ground transportation.

But enough of worrying about our descendants' problems. Besides these far off visions of aviation, I have given you a glimpse of what NASA thinks we can actually put into the commercial aircraft built in 1985 to conserve fuel, perhaps 50 percent less fuel than we use today. Of course, this is just a goal. I do not know if we will reach it, but two things are certain: First, the generation of commercial aircraft built in 1985 or so will be significantly more fuel efficient than what we have today, and, second, if we do not give NASA the money it needs for aircraft fuel efficiency research now, we will be giving it to the Arabs as petrodollars later on.

NASA can stimulate new jobs for Americans, encourage the design of better aircraft for export, and cause a significant reduction in our dependence on oil imports from the Arabs. I'd say that's a bargain! I'd say I would pay NASA even more than they can save us in oil imports just to keep those dollars in our pockets and out of a sheik's moneybelt.

But there is one condition on my support of this aircraft fuel efficiency effort. I am wholeheartedly behind it, except that I would never want to see it become the bargaining chip for lowering safety standards or for serious degradation in our aircraft environmental goals. In the past in the commercial aircraft industry, safety has never taken a back seat to aircraft performance. I see no reason to mar that record now. I consider the environmental standards to be in the same category as safety. This may look like we are putting the aircraft manufacturers in the middle of a tug of war, but in

reality everyone is pulling them in the same direction: toward a more desirable and saleable aircraft.

Finally, I want to mention a segment of aviation that has long been overlooked. General aviation aircraft flew 80 million passengers last year; it is a fundamental transportation mode in many parts of our country. And one-third of the light planes produced in the United States are exported, so general aviation aircraft are also an important part of our technological exports.

Because of its widespread use and export, I believe light aircraft should be included in the fuel efficiency program. I was much disturbed last month by a NASA official's statement that the basic technology present in the light plane has not changed since the late 1940's. In other words, we are just beginning on the learning curve in general aviation.

The general aviation manufacturers are, of course, much smaller than the air transport manufacturers, and therefore their research budgets are smaller as well. For this reason, I believe NASA can be of even greater assistance to general aviation in improving fuel economy as well as with other problems. Already, the Piper Aircraft Company, working with NASA in a NASA-funded project, has put the supercritical wing on one of its light airplanes for tests. (See fig. 7.) Engineers estimate that they will get a 10 percent saving in fuel and, in addition, a smoother ride and safer rate of climb capability.

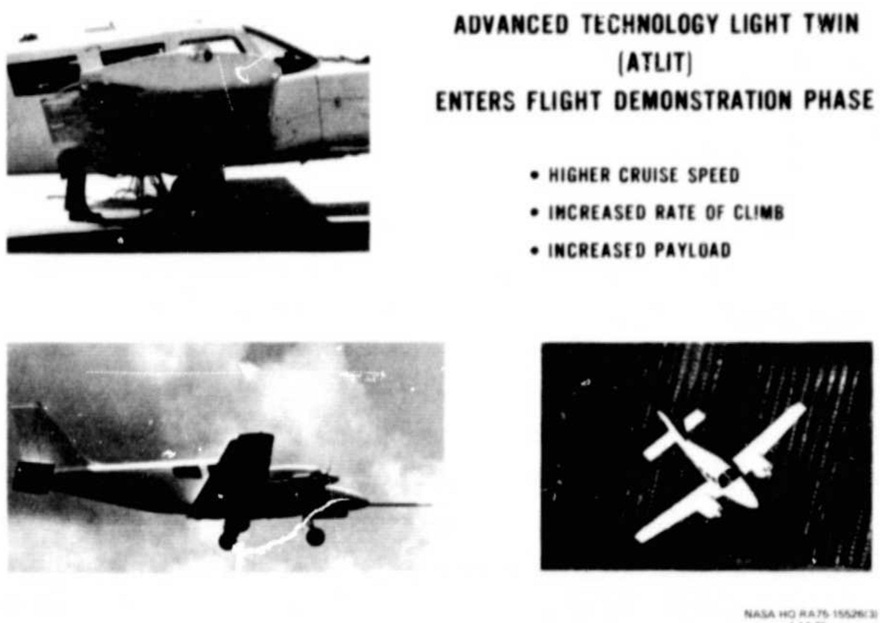

Figure 7. - NASA's application of supercritical wing and high lift devices to light airplane.

Another big problem for general aviation is meeting the tough 1979 EPA emissions standards for aircraft piston engines. You may have heard that NASA has been experimenting with the injection at the carburetor of very small amounts of hydrogen with the gasoline in automobile engines. The hydrogen is obtained by bleeding a little gasoline off and catalytically cracking it in a small device attached to the engine. Not only are the emissions reduced, but fuel economy is improved as well, mainly because the engine can be run much leaner than normal. This system looked so good on automobiles that NASA has begun experimenting with light aircraft engines. Researchers found that, not only are the aircraft engine emissions drastically reduced, but, because of the leaner fuel mixture, fuel economy may be 20 percent greater at cruise power. So it appears that environmental pollution controls and fuel economy do not have to be mutually exclusive on light planes at least.

I want to point out here that these two examples of NASA contributions to general aviation, the supercritical wing and hydrogen injection, were adapted from NASA efforts in other areas. Let's face it, it is hand-me-down technology. That is great if it works, but I would like to see NASA treat general aviation, not as an afterthought, but rather as commercial aviation's twin. I am not suggesting that the research funding for each should be equal, but I do think that it is time general aviation received some primary attention.

In closing, I just want to lay to rest some fears that I may have caused the audience here. You see, the chief argument surrounding the pterosaur today is whether it flapped its wings or merely glided; in other words, whether it had a propulsion system. When NASA and industry hatch the next generation, a more fuel efficient generation of pterosaurs, I can assure you that they will have propulsion systems, whether or not the prehistoric version did. Up to now increases in propulsion efficiency have been far and away the chief reason for improvements in aircraft efficiency; I hope that you will continue to lead the effort to hatch a leaner pterosaur.